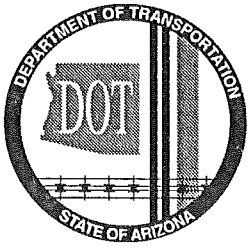

ARIZONA DEPARTMENT OF TRANSPORTATION

REPORT NUMBER: FHWA-AZ89-250

EFFECTS OF IN-STREAM MINING ON CHANNEL STABILITY

Volume III: Appendices

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16. Abstract

This report contains the Appendices to Volume II, Final Report, addressing the impacts of in-stream sand and gravel mining on channel stability in Arizona. The information contained in the Appendices provides further documentation in support of the major chapters of the final report. Topics addressed in the appendices include: summary of response to sand and gravel mining questionnaires, summary of gravel mining and sediment transport studies on major Arizona rivers, review of litigation related to in-stream mining, long-term procedure technical appendix, documentation of computer program for short-term Channel Response due to In-Stream Mining (CRISM), documentation of computer program HEC-2SR for single-event river response simulation, topographic dataset, bed-material gradation dataset, hydrologic dataset, and mining activity dataset.

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APPENDIX A. SUMMARY OF RESPONSES TO SAND AND GRAVEL MINING QUESTIONNAIRE

A.1 Introduction

In order to establish a comprehensive data base for this research project, questionnaires were developed to solicit relevant information from: 1) regulatory agencies; 2) sand and gravel operators; and 3) consulting engineers who have been involved in preparing technical studies for mining permit applications. This summary provides an overview of the input received from the questionnaire respondents.

A.2 General

Three different questionnaires were developed with questions oriented towards obtaining the type of data available from each of the three groups (i.e., regulatory agencies, sand and gravel operators, and consulting engineers). A total of 190 questionnaires were sent with the following results:

Respondent	No. of Questionnaires Transmitted	No. of Questionnaires Returned	% Rtnd
1. Regulatory Agencies	32	31	97
2. Sand & Gravel Operators	152	12	8
3. Consulting Engineers	6	5	83

A.2.1 General Issues and Trends

A review of the respondents' comments identified the following general issues and trends related to in-stream sand and gravel mining:

- Several respondents expressed concern regarding the feasibility of developing uniform guidelines at the State government level which would be justifiably applicable to all river systems within the State.

- Some disagreement exists among respondents regarding which governing body should be responsible for regulating sand and gravel mining operations; however, a general consensus is that regulation should be left up to local jurisdictions backed by a State enabling law and physically based engineering standards.

- At the present time, the primary vehicle for regulation of in-stream sand and gravel operations is through

local zoning and floodplain ordinances applied on a site specific basis. Requirements for issuance of a Floodplain Use Permit are tailored to the specific operation under consideration.

- Enforcement is carried out first through contact with the operator and, if necessary, then through litigation in civil court. Several respondents have been or are currently involved in litigation both as defendants and/or plaintiffs. (A current court case examines the issue of whether the in-stream sand and gravel mining operation is exempt from zoning ordinance requirements.)

- The primary benefit of in-stream sand and gravel mining was seen as providing an economical, convenient source of quality construction material upon which virtually all development of public and private infrastructure depends. Other benefits mentioned included: 1) increased channel capacity; 2) reduced potential for overbank flooding in some areas due to channel degradation; 3) partial runoff storage; 4) minor, local groundwater recharge; and 5) profits for companies that leads to the creation of jobs and an increased tax base.

- It was noted that the issue of damaged transportation structures was not exclusively related to the impacts of sand and gravel mining. Also cited as a contributing factor to structure damage was a lack of proper planning on the part of engineers in predicting the magnitude of severe flood events and in designing structural foundations to withstand such flooding conditions. An in-depth study was called for to evaluate the cost effectiveness of designing new bridge foundations and/or refurbishing existing structures to handle 100-year flows versus the economic impacts of the loss of production of low-cost aggregates.

- It was suggested that environmental concerns and long-term consequences be considered as they relate to the benefit of mining a particular site. A benefit/cost approach to regulating in-stream mining would weigh the type, quality and need for material versus the cost of mitigating mining impacts (e.g., grade control structures, site restoration, etc.)

- A recommended technical approach would evaluate the long-term stability of the overall sediment system for a given river reach and then analyze the local effects resulting from in-stream mining within that system. The analysis should not always be based on the impacts of an individual pit, since such an approach might overlook the combined effect of adjacent operations on

the overall system.

A.2.2 Basis of Regulatory Program

The questionnaires solicited respondents' input regarding the objectives, procedures and criteria upon which a state-wide regulatory program should be based.

The main objective of the regulatory program was seen as preventing/mitigating negative impacts (due to mining operations) upon stream stability, water quality, adjacent property owners, and in-stream structures and improvements.

The procedures by which this objective would be pursued were also addressed. The majority of regulatory agency respondents supported regulation of gravel operators through local zoning and floodplain ordinances backed by State law and subject to State audit to ensure compliance. New operations, or expansion of existing operations onto new land, would be restricted so that existing or planned improvements were not at risk, while existing operations could be accommodated through some type of "grandfather" clause.

Although respondents provided information regarding criteria currently used to evaluate impacts of sand and gravel mining on channel stability, in-stream structures and bank protection, they provided very little information of specific technical procedures that were used to analyze the criteria. The following is a summary of respondents' comments regarding technical criteria that should be used in reviewing permits for in-stream mining:

1. Restrictions on distance from gravel pit to bridges, flood control structures, utilities and urban development.

2. Restriction on pit depth and side slopes.

3. Limitations on upstream headcutting, bank erosion, and downstream degradation.

4. Determination of "safe yield" through analysis of material extracted versus sediment supplied to mined reach.

5. Investigation of manner in which excavation will proceed (pit geometrics), excavation method to be used, and duration of mining activities.

6. Restrictions on stockpiling in the floodway.

7. Restrictions on diverting channels with diversion dikes at mining locations.

8. Requiring sediment routing analysis to consider different flow frequencies and durations.

9. Requiring grade control structures, as needed.

10. Requiring environmental rehabilitation and restoration for aesthetic purposes.

A.3 Questionnaire Response Summary

A.3.1 Regulatory Agencies

The regulatory agencies were asked to provide facts concerning the sand and gravel mining operations within their jurisdiction, regulatory guidelines/policies, enforcement programs and litigation information. If they were involved in the design, regulation or maintenance of in-stream structures, input regarding design methodologies and considerations was also requested.

A.3.1.1 Federal Agencies

The federal agencies responding to the questionnaire do not regulate the sand and gravel mining operations within their jurisdiction. The USDA Soil Conservation Service does consider erosion/sedimentation processes in the design of in-stream flood control structures and does account for the effects of sand and gravel mining upon the project design, as needed. Of concern to the U.S. Fish & Wildlife Service is the long-term impacts to fish and wildlife resources as a result of in-stream mining operations.

The U.S. Army Corps of Engineers (COE) Regulatory Branch administers a permit program under Section 404 of the Clean Water Act. Any person, firm or governmental agency planning work in "waters of the United States" must first obtain a permit from the COE. Activities related to sand and gravel mining which require permits are the disposal of fill or the discharge of dredged or fill materials in "waters of the United States" which cause the loss or substantial adverse modification of 10 acres or more. Under the provisions of Nationwide General Permit Number 26, for those discharges which adversely impact 1 to 10 acres, the COE District Engineer must be notified before work begins. This nationwide general permit eliminates the need for further permit processing by the COE for discharges which cause the substantial loss or adverse modification of less than 1 acre. In addition, sand and gravel operations outside the 20-year floodplain need not apply for individual permits.

A.3.1.2 State Agencies

The Arizona Department of Transportation (ADOT) does not directly regulate sand and gravel mining operations throughout the State. However, ADOT does control the use of materials on highway construction projects through their construction specifications. Section 106.03 of the 1985 ADOT Supplemental Specifications limits the use of material sources situated within the 100-year floodplain of a watercourse, and located within one mile upstream and two miles downstream of a highway structure or

roadway crossing. Within these boundaries, existing commercial sources may not be utilized as a source of borrow nor will any new source or existing non-commercial source be approved for any materials.

> "The location of any new material source or existing non-commercial material source proposed for use on this project shall be reviewed by the appropriate agency having flood plain management jurisdiction for the area in which the proposed source is located. The contractor shall obtain a letter from the agency addressed to the Engineer certifying that the location of the proposed source conforms to the requirements of the Specifications."[1]

In monitoring department-owned sources in the floodplain, ADOT requires the Materials Section to evaluate potential risk to public or private improvements located one mile up and downstream of the materials operation. A mining plan and an environmental assessment, which includes a hydraulic study, is required under certain conditions.

The Arizona Department of Health Services (ADHS) principal authority related to mining is to control the discharge of pollutants from point and non-point sources. The point source control program is implemented by National Pollutant Discharge Elimination System (NPDES) permits, issued under Section 402 of the Federal Clean Water Act. The non-point program consists of compliance evaluations in waters potentially impacted by diffused source discharges. If standards are exceeded, or protected water uses are impaired in these waters, then corrective actions are required. Water line crossings for proposed projects for water supply and wastewater systems receive detailed engineering reviews before approval to construct is granted. If buried lines cross watercourses, the impact of gravel mining and channel scouring are considered on a site-specific basis.

None of the respondents from State agencies had been involved in litigation related to sand and gravel mining operations.

A.3.1.3 County Agencies

Two-thirds of the county respondents have in-stream sand and gravel mining operations within their jurisdiction. It is interesting to note that two-thirds of county respondents do regulate mining operations; however, those regulating are not necessarily the same counties as those with mining activity occurring.

---

[1]Arizona Department of Transportation, Standard Specifications for Road and Bridge Construction, 1985 Supplement, Sec. 106.03.

The counties regulate sand and gravel mining through floodplain and zoning boards. Floodplain Use Permits are required for new mines and major expansions of existing mining operations. Enforcement may require legal action; one-half of county respondents are involved in litigation related to sand and gravel mining as both defendant and/or plaintiff.

Cochise County has budgeted funds for this fiscal year to commence a mapping and study program designed to more effectively regulate sand and gravel mining operation within their jurisdiction.

A.3.1.4 Local Agencies

One-half of the local respondents have in-stream sand and gravel mining operations within their jurisdiction. One-half of the respondents also regulate in-stream mining in the form of Floodplain Use Permits with supplemental extraction data supplied by the operator. One of the local respondents had been involved in litigation related to sand and gravel operations.

At the local level, there is concern that mining operations tend to have a negative impact on adjacent property values. There is support for environmental rehabilitation through proper site restoration in these areas.

The City of Peoria has stipulated that the City will receive, as a license fee, a per ton royalty for material which is extracted for commercial use at off-site locations. This fee is placed in the flood control budget. The operator is responsible for submitting monthly reports indicating the amount of material removed.

A.3.2 Sand and Gravel Operators

The sand and gravel mining operators were asked to provide facts concerning their facilities resources for all operations they have conducted in the State during the past five years. Also requested were data regarding the total amount of rock products they produce and sell in Arizona, and estimates of future annual extraction rates for the next five years. In addition, information was solicited concerning regulatory compliance requirements, permit application submittals, and design practices, if applicable. Responses were received from individual operators.

The operators felt that there are some inconsistencies on the part of regulatory agencies with regard to requirements for issuance of permits for sand and gravel operations. The operators feel the agencies are uncertain as to what is really necessary to assure indemnity from litigation, and that engineering firms have over-emphasized to these agencies the need for sophisticated, costly studies to adequately assess mining impacts. This results in increased cost of aggregate materials to the end user. The most important economical factor in the total cost of gravel products is the transportation cost incurred

in hauling material from pit to end user, thus making a case for maintaining gravel pits in close proximity to development sites.

The turnaround time for regulatory agencies to process permit applications varys from two months to more than one year. The average total cost to the operator for completion of a permit application was estimated to be $50,000. Major factors affecting the cost of submitting a permit application include:

1. Operation location relative to in-stream structures
2. Operation size
3. River characteristics
4. Varying requirements of different regulatory agencies.

The operators emphasize that a statewide program should consider the impact to the overall economy resulting from regulating or restricting the recovery of limited aggregate reserves which, in the major metropolitan areas, are centrally located to the market, therefore, providing low cost building materials for the State's growth. The operators are concerned about the economic impact on the sand and gravel industry as related to the cost of compliance with regulatory controls.

A.3.3 Consulting Engineers

The questionnaires sent to consulting engineers requested information concerning the criteria and procedures used in evaluating the effect of sand and gravel mining facilities on channel stability and the design of in-stream structural improvements. Input was solicited regarding the preparation of permit applications for sand and gravel mining operations.

Respondents identified the following as major hazards to in-stream structures caused by the presence of sand and gravel operations:

- degradation/scour potential
- headcut propagation
- significant lateral channel migration impacts
- concentration/diversion of flows at mining sites
- perpetuation of mining activities

The criteria used to assess these hazards included:

- sediment supply and balance
- upstream and downstream channel conditions
- pit geometrics/volume
- set-back distances
- proximity of structural improvements

The following procedures and methodologies are used to evaluate the effect of sand and gravel mining operations on channel stability and in-stream structural integrity:

- computer programs: HEC-2, HEC-6, FLUVIAL-11, IALLUVIAL, QUASED, PIT, SETTLE
- empirical sediment transport capacity equations
- qualitative geomorphic assessments
- hydrograph development techniques

In the preparation and submittal of permit applications for sand and gravel mining operations, it was estimated that approximately 70-80% of the applications were approved. The percentage approved increased with the operation's acceptance of modifications to the operating procedures or mining plan.

A.4 Interview Summary

As a follow-up to the questionnaire response, personal interviews were conducted with four regulatory agencies to solicit additional information relative to sand and gravel operations. The agencies interviewed include the Arizona Department of Transportation Structures Section, the Pima County Department of Transportation and Flood Control District, the Flood Control District of Maricopa County, and the City of Phoenix.

A.4.1 Interview Agenda

A brief synopsis of the general issues and trends identified from the questionnaire response (Section A.2.1) was presented to interviewees. Their input and feedback on these issues was then discussed. Additional information was requested on appropriate methodologies and technical procedures used in the analysis of the impact of sand and gravel operations on channel stability. The current status of regulation of mining operations at a federal, state, county, and local level was reviewed. The strong points and shortcomings of existing regulatory practices were evaluated. In addition, alternative approaches to regulation of sand and gravel operations were explored with attention to the appropriate means of administering and funding any recommended approach. The availability of technical data was discussed, especially in areas where damage has occurred in the past that was allegedly aggravated by the presence of sand and gravel operations. Data availability would impact the potential for use of these sites for case history studies. Finally, pertinent court cases, if any, within the area of jurisdiction of those interviewed were briefly reviewed.

A.4.2 Interview Response

A review of the questionnaire response indicated that very little information was received regarding specific technical procedures used in the analysis of in-stream pit impacts. Most respondents recognized that in-stream sand and gravel mining could impact channel stability, but few were able to provide details regarding appropriate methodologies for quantifying such impacts.

Those interviewed currently evaluate impacts on a case-by-case basis relying on various methodologies and engineering judgement. Two of those interviewed were cautious about relying solely on sediment routing model results and felt the regulations should allow for some simple, generalized guidelines and measures for use in analyzing sand and gravel mining impacts. The Flood Control District of Maricopa County (FCDMC) has relied on the use of design measures to mitigate impacts. Mitigation alternatives include: 1) low-flow side weirs or spillways which allow drowning of in-stream pits during periods of channel flow; 2) provisions for protection at the upstream side of a pit from headcutting by installing dumped or grouted riprap; and 3) conservative setbacks as an alternative to stabilization measures.

Those interviewed generally agreed there was a need to establish guidelines for proper use of analytical techniques and to implement a standardized approach so that consistency is maintained. Sand and gravel operators have been concerned that local board decisions have not been consistent nor based on adequate techniques. The need to develop criteria and guidelines addressing several specific areas was identified. These areas include:

- appropriate flood events to use in sediment routing models
- evaluation of annual sediment yield
- determination of a profile line above which extraction is permitted
- setback distances and development plans for overbank pits
- guidelines for long-term sediment yield modeling
- proper analysis techniques for determining the cumulative impacts of several adjacent pits on the overall system.

The interviewees support more comprehensive study on a river basin level to evaluate an overall river system rather than relying on site specific analyses which do not consider cumulative impacts. FCDMC is currently discussing the possibility of conducting several floodplain/environmental river system studies which might integrate well with river basin level studies of gravel mining impacts.

With regard to regulation, discussion centered on a workable regulatory approach to in-stream sand and gravel operations. A three-tier approach recommended by SLA was discussed with each of those interviewed and is summarized as follows:

1. Based on data to be collected by SLA during subsequent tasks of this research project, an effort will be made to develop regionalized envelope curves for major river basins within the State. Depending on the availability of data, these curves will be developed to provide guidelines relating pit depth to: 1) headcut length; 2) downstream degradation; 3) lateral migration distance; and 4) any other parameters that may be

deemed necessary. Although these envelope curves will be based on data specific to different river basins within the State, they will have to incorporate a degree of conservatism that will permit their application to any site within the region for which they were developed. The factor of safety that would have to be included under such a scheme may make the envelope curves very restrictive in terms of allowable excavation limits.

2. At the county/local level, general river basin studies would be recommended for basins within county/local jurisdiction in order to develop an "optimal red-line standard" defining both the lateral and vertical limits for sand and gravel mining. These guidelines, which would be less conservative and more site-specific than the envelope curves developed under Level 1, would define the extraction slopes, elevations, and width along the mining reach. These studies could be funded through a tax on sand and gravel extractions (levied on a per ton basis) or possibly, through State appropriations similar to those previously approved for flood control projects.

3. For those individuals who feel the envelope curves or "red-line" approach are too conservative, a third alternative would be available. This third level of this multi-tier approach would allow for a site specific engineering analysis to be performed at the sand and gravel operators' discretion and expense. This third level of analysis could be invoked in those cases where the sand and gravel operators feel the envelope curves and "optimal red-line standard" are unfairly restricting the volume of material that could potentially be excavated from a specific site. This third tier of analysis would provide a very detailed site-specific study of a pit. The objective of this study would be to provide technical documentation that would show the excavation limits established by the envelope curves or "optimal red-line standard" could be exceeded without causing damage to adjacent property.

With some reservations, those interviewed generally support the three-tier approach. At the present time, the regulatory approach at the county level is two-tiered using either conservative guidelines or detailed site specific studies. A middle ground, as represented by a "red-line standard", would help to reduce the number of site specific studies required.

The opinion of those interviewed was divided over the role of a State-level authority to monitor this program. It was recognized that a State-level authority would be needed to assist smaller counties (without the expertise in this field) by providing technical support and/or developing model ordinances.

However, one of those interviewed did not see a need for statewide resource identification and there was some concern that a State-level regulation could serve to interfere with local decisions regarding mining operations. It was felt such interference would be to the detriment of the local community. To circumvent this issue, it was proposed that the regulatory control be maintained at the county level while allowing the incorporated cities and towns to assume the responsibility of regulation of mining activities. Similar to floodplain management responsibility under ARS Title 48, Section 3610, the cities or towns could opt to let the county flood control district assume the gravel mining regulatory function for them. Thus large cities with adequate technical staff could support this regulatory function themselves while the flood control districts could support small cities and towns.

Other issues of concern to those interviewed are summarized below:

- FCDMC is concerned with the need to regulate in-stream gravel mining operations which are outside of official FEMA delineated floodplains. ARS Title 48 and the county floodplain ordinance do not cover these cases.

- The Pima County Department of Transportation and Flood Control District (PCDOT & FCD) is concerned with adequate enforcement of operator compliance with permit stipulations. PCDOT & FCD recommends consideration be given to requiring assurance of compliance by the operators through bonds, etc.

- "Grandfathering in" existing gravel mining operations can be problematic as to where to establish a cut-off point.

- Consideration should be given to requiring rehabilitation and restoration of the site following the termination of a mining operation.

- In general, current regulatory policy is not opposed to in-stream mining when there is a surplus in the sediment balance of the reach being mined. There is support for allowing the scalping of river bars and vegetation to restore channel conveyance. The use of sand and gravel mining as a channel clearing function is seen as beneficial, realizing there are possible long-term degradational impacts on the river being mined.

A.5 Damage Inventory

This section includes an inventory of damage to public or private property allegedly due to, or in part from, in-stream sand and gravel mining operations. This information was taken

from the questionnaires returned to SLA and is presented here for information purposes only. The respondents that provided this information do not indicate what proof, if any, has been developed to link the sand and gravel operations to the alleged damage. This information may be used as a source of data for case history studies that will be pursued in subsequent sections of this research project.

1. Gila River-damage to streets and adjacent lands in Goodyear, AZ
2. Salt River-I-10 bridge foundation (1979, 1980, 1981)
3. Agua Fria River-Indian School Road bridge failure (Feb., 1980)
4. Agua Fria River-Glendale Avenue crossing (Dec., 1978)
5. Agua Fria River-Rose Garden Lane crossing (Dec., 1978)
6. Agua Fria River-East overbank upstream of Northern Avenue crossing (Dec., 1978)
7. Verde River-I-17 bridge crossing
8. Verde River-Vicinity of Cottonwood, AZ, damage to downstream properties, destabilized banks, reduced riparian vegetation/biota
9. Verde River-upstream of Camp Verde, AZ
10. Santa Cruz River-Silverlake Road bridge pier exposure
11. Santa Cruz River-T13S, R12E, Sec. 1 and T12S, R12E, Sec. 35, capture of overbank pits resulting in increased channel width and lateral migration
12. Pantano Wash-increased lateral migration between Houghton Road and Rincon Creek (1983)
13. San Pedro River-impact upon fish and wildlife resources
14. Ehrenberg, AZ-some damming and ponding exacerbated damage due to flood of July 21, 1986
15. Cottonwood Wash-aggradation/degradation at SR77 bridge, Snowflake, AZ
16. Granite Creek-damage to U.S. Highway 89 bridge near Prescott, AZ
17. Kingman, AZ-exposure of utility line crossings in channel

A.6 Recommended River Segments

The following river segments were recommended for detailed study of in-stream sand and gravel mining operations:

1. Gila River-Gillespie Dam to Salt River confluence
2. Gila River-Salt River confluence to Coolidge Dam
3. Salt River-Gila River confluence to Granite Reef Dam
4. Agua Fria River-Salt River confluence to Waddell Dam
5. New River-Agua Fria River confluence to Maricopa-Yavapai County line
6. Hassayampa River-U.S. Highway 60-89 bridge to 1/2-mile upstream of bridge
7. Verde River-Salt River confluence to Paulden, AZ
8. Oak Creek-limits unspecified
9. Wet and Dry Beaver Creek-limits unspecified

10. Santa Cruz River-I-10 bridge (Martinez Hill) to Avra Valley Road
11. Rillito Creek-Santa Cruz River confluence to Craycroft Road
12. Pantano Wash-Tanque Verde Wash confluence to 5-6 miles upstream of Houghton Road
13. Santa Cruz River, Sonoita Creek, Potrero Creek, and Harshaw Creek-within Santa Cruz County (limits unspecified)
14. San Pedro River-Hereford to Winkelman, AZ
15. San Pedro River, Garden Canyon Wash, and Cayote Wash-immediately outside Sierra Vista city limits
16. Rye Creek-4 miles upstream to 4 miles downstream of SR87
17. Tyson Wash-5 miles upstream to 2 miles downstream of Quartzite, AZ
18. Ehrenberg, AZ-site of flooding of July 21, 1986 (limits unspecified)
19. Cottonwood Wash-between SR277 and SR77 bridges in Snowflake, AZ
20. Sols Wash-in vicinity of River Street, Wickenburg, AZ

QUESTIONNAIRE

Effects of In-Stream Mining on Channel Stability

Arizona Department of Transportation

Project Number HPR-PL-1-31(250)

Name of Agency: _____

Name of Respondent: _____

Area of Jurisdiction: _____

A. GENERAL	YES	NO
1. Do you have in-stream sand and gravel mining operations within your jurisdiction?	___	___
2. Do you regulate in-stream sand and gravel mining operations?	___	___

3. If the answer to Question No. A.2 is yes, please answer the following questions.

   a. What year did the regulatory program start? _____

   b. How many permits have been issued....

      - since the program started? _____

      - in the last five years? _____

      - in the last year? _____

   c. How many gravel mining operations are currently active within your jurisdiction? _____

4. If you regulate in-stream sand and gravel mining, do you have written guidelines/policies?	___	___

   If yes, please attach a copy of these guidelines/policies.

5. If you regulate in-stream sand and gravel mining, what kind of enforcement program do you have? _____

_____

_____

_____

6. If you do not regulate in-stream sand and gravel mining, does any other agency have this responsibility in your jurisdiction? ___ ___

   If yes, please identify this agency and give the name of the person in charge. _____

7. If there is no regulation of in-stream sand and gravel mining in your jurisdiction, do you feel there should be regulation? ___ ___

8. If a state-wide program were to be adopted to regulate in-stream sand and gravel mining, upon what criteria or factors should such a program be based? _____

9. Do you perceive that damage to public or private property has occurred due to, or in part from, in-stream sand and gravel mining operations? ___ ___

   If yes, please list cases and note when and where the damage took place. _____

10. What benefits to public or private property has accrued due to, or in part from, in-stream sand and gravel operations? _____

11. Has your agency been involved in litigation attributed

to any damage listed under Question A.9? ___ ___

Was your agency the plaintiff or defendent? _____

Please state the status or outcome of the litigation and the name and date of the case. _____

_____

_____

_____

B. DESIGN PRACTICE	YES	NO
1. Does your agency design, regulate, and/or maintain any in-stream (or floodplain) structures (e.g., bridges, utility crossings or alignments, flood control structures, etc.)? (Please circle which function(s) your agency performs.)	___	___
If yes, do you...		
a. consider the effects of erosion/sedimentation (e.g., scour, lateral movement of the channel banks, sediment deposition, etc.) on the design/regulation/maintenance of these structures?	___	___
b. consider the effect of in-stream sand and gravel mining on the design/regulation/maintenance of these structures?	___	___
2. If the answer to Question B.1.b. is yes, please answer the following questions. Do you base structure design requirements on the following gravel pit characteristics:		
a. Pit depth?	___	___
b. Distance from gravel pit to structure?	___	___
c. Pit side-slopes?	___	___
d. Other? _____		

3. If the answer to any part of Question B.2. is yes, please state or include the design methods used. Please list and name the source of information from which these methods were developed (e.g., computer programs, design manuals, agency reports, research reports, collected data,

in-house analysis, etc.) _____

_____

_____

_____

C. **INFORMATION** YES NO

1. Do you know of any data or reports that would be helpful to this research project? ___ ___

   If yes, please provide a copy of the data or a citation for the reports. _____

_____

_____

_____

2. Would you recommend any Arizona river segments in your area of jurisdiction be included in a detailed study of in-stream sand and gravel mining operations? ___ ___

   If yes, please list recommended river segements. Note segment location (approximate starting and ending points) and provide a brief description of river features and gravel mining effects that prompt you to recommend this river. _____

_____

_____

_____

D. **ADDITIONAL COMMENTS.** Please note below any additional comments which you feel are relevant to this study. (Please feel free to use attachments, if necessary). _____

_____

_____

_____

QUESTIONNAIRE (Revised 9/24/86)

Effects of In-Stream Mining on Channel Stability

Arizona Department of Transportation

Project Number HPR-PL-1-31(250)

Name of Company: _____

Name of Respondent: _____

A. RESOURCE INFORMATION

1. Please complete Table 1 (attached) for sand and gravel mining operations that you have conducted from pits located within a floodplain[1] in the State of Arizona during the past five years.

2. Considering product demand and resource areas available to your company, please complete Table 2 and estimate your company's future annual production from pits within a floodplain[1] for the next five years.

TABLE 2. ESTIMATED FUTURE ANNUAL PRODUCTION

Facility Number	Years From Present				
	1	2	3	4	5

[1] This refers to areas within the designated flood hazard boundary area as defined on a flood hazard boundary map issued by the Federal Emergency Management Agency.

TABLE 1. FACILITY RESOURCE INFORMATION
(Revised 9/24/86)

Facility Number	Location (County and Nearest Town)	River Name	Opening Date (mo/yr)	Closing Date (mo/yr)	Material Reserves (cu yd)		Extraction Rate (cu yd/yr)
					Initial	Current	

B. REGULATORY COMPLIANCE

1. List the local, state and/or federal agencies to which your company has submitted permit applications for in-stream sand and gravel mining as related to floodplain locations in Arizona.

2. Please indicate (without reference to specific permit submittals) the average length of time (in months) required for the regulatory agency to process a permit application submitted by your company. (That is, the time from the date the permit was submitted to the date the permit was either granted or denied.) Also, indicate the minimum and maximum length of time that was required to process a permit application.

3. Based on your companies experience, please estimate the average total cost (survey, engineering, testing, etc.) required to complete a permit application. Also, estimate the maximum and minimum cost for submitting permit applications.

4. What are the major factors that lead to different costs for submitting permits? (circle applicable factors)

   a. Operation location to in-stream structures (e.g., bridges)
   b. Operation size (pit volume, depth, etc.)
   c. River characteristics
   d. Varying requirements of different regulatory agencies
   e. Public comment
   d. Other factors (please list)

   _____

   _____

   _____

5. How many permit applications have you submitted? _____

   a. How many were approved? _____

      How many were denied? _____

   b. To the best of your knowledge, state the reasons for permit denial. _____

   _____

   _____

6. Has your firm been involved in litigation attributed to effects of sand and gravel mining on in-stream or floodplain structures? YES ___ NO ___

   Was your firm the plaintiff or the defendent? _____

   Please state the status or outcome of the litigation, and the name and date of the case. _____

   _____

   _____

   _____

7. If a state-wide program were to be adopted to regulate in-stream sand and gravel mining, upon what criteria or factors should such a program be based? _____

   _____

8. Based on your experience, what benefits do in-stream gravel mining operations offer? _____

C. DESIGN PRACTICE

	YES	NO
1. Does your company design/analyze in-stream sand and gravel mining facilities using your own engineering staff?	___	___

If your own engineering staff is used, please answer the following questions.

a. What are the design criteria you use to assess effects of mining on channel stability (e.g., sediment supply, pit volume, pit shape, trap efficiency, location with respect to bridges or utilities, etc.)? _____

b. Do you use specific design procedures in the analysis of a sand and gravel pit operation to assess channel stability? ___ ___

If yes, please cite the source of these procedures (e.g., computer programs, design manuals, reports, articles, etc.). _____

c. Based on your experience, what factors or parameters related to channel stability are the most difficult

to evaluate in the analysis of sand and gravel mining facilities? _____

_____

_____

_____

D. GENERAL INFORMATION

	YES	NO
1. Do you know of any data or reports that would be helpful to this research project?	___	___
2. Would you recommend any Arizona river segments that should be included as a detailed study of in-stream sand and gravel mining operations?	___	___

If yes, please provide references to where this information could be obtained. _____

_____

_____

_____

If yes, please list recommended river segments. Note segment location (approximate starting and ending points) and provide a brief description of river features and gravel mining effects that prompt you to recommend this river segment. _____

_____

_____

_____

_____

_____

_____

D. ADDITIONAL COMMENTS. Please note below any additional comments which you feel are relevant to this study. (Please feel free to use attachments, if necessary.) _____

_____

QUESTIONNAIRE

Effects of In-Stream Mining on Channel Stability

Arizona Department of Transportation

Project Number HPR-PL-1-31(250)

Name of Firm: _____

Name of Respondent: _____

A. DESIGN PRACTICE	YES	NO
1. Has your firm designed and/or analyzed in-stream sand and gravel mining facilities?	___	___

If yes, please answer the following questions.

a. What are the design criteria you use to assess effects of mining on channel stability (e.g., sediment supply, pit volume, pit shape, trap efficiency, location with respect to bridges or utilities, etc.)? _____

_____

_____

_____

b. Do you use specific design procedures in the analysis of a sand and gravel pit operation to assess channel stability? ___ ___

If yes, please list and name the source of these procedures (e.g., computer programs, design manuals, reports, articles, etc.). _____

_____

_____

_____

2. Do you consider the effect of in-stream sand and gravel mining during the design of in-stream structures (e.g., bridges, utility crossings or alignments, channel stabilization works, etc.)? ___ ___

If yes, please answer the following questions.

a. What are the design criteria you use to assess

potential effects of mining on the structure (e.g., distance of the pit from the structure)? _____

b. Do you use specific analysis procedures in the design of a structure to assess potential problems related to in-stream mining? ___ ___

If yes, please list and name the source of these procedures (e.g., computer programs, design manuals, reports, articles, etc.). _____

c. Based on your experience, what are the major hazards to in-stream structures caused by the presence of sand and gravel operations? Please note which of these hazards are the most difficult to accurately assess during design. _____

d. Based on your experience, what are the major benefits from in-stream sand and gravel mining operations. _____

3. Has your firm been involved in litigation attributed to effects of sand and gravel mining on in-stream structures? ___ ___

Was your firm representing the plaintiff or the defendent? _____

Please state the status or outcome of the litigation, and the name and date of the case. _____

_____

_____

_____

B. REGULATORY COMPLIANCE

	YES	NO
1. Has your firm prepared permit application information for in-stream sand and gravel mining operations?	___	___

If yes, please answer the following questions.

a. Please list the agency(s) to which the permit submittal(s) was(were) made and the approximate date of the submittal(s). _____

_____

_____

_____

b. Based on your experience, please estimate the total cost (your fee, subcontracted services, testing, etc.) required to complete permit application preparation for the following size sand and gravel mining operations in Arizona.

100,000 cu yd or less _____

500,000 cu yd or less _____

1,000,000 cu yd or less _____

5,000,000 cu yd or less _____

Greater than 5,000,000 cu yd _____

c. Please indicate (without naming specific cases) the length of time (in months) from the date the permit was submitted to the date the permit was either granted or denied. _____

_____

_____

d. Please indicate (approximately) the percentage of permit applications approved and the percent denied. _____

e. Please list the reasons why permits were denied. _____

2. Has your firm provided permit application review services of in-stream sand and gravel mining operations to a local, state, or federal agency? ___ ___

If yes, please answer the following questions.

a. Please list agencies for which you have provided review services and give the total number of reviews that your firm has conducted. _____

b. In what percent of the cases, as a part of the review process, did you conduct a separate analysis of the potential impacts on in-stream mining on channel stability in addition to the analysis submitted by the applicant? _____

c. What was the average length of time required to conduct your review? _____

What was the longest and shortest period of time required?

C. GENERAL INFORMATION

	YES	NO
1. Do you know of any data or reports that would be helpful to this research project?	___	___

If yes, please provide references as to where this information could be obtained. _____

	YES	NO
2. Would you recommend any Arizona river segments that should be included as a detailed study of in-stream sand and gravel mining operations?	___	___

If yes, please list recommended river segments. Note segment location (approximate starting and ending points) and provide a brief description of river features and gravel mining effects that prompt you to recommend this river segment. _____

D. ADDITIONAL COMMENTS. Please note below any additional comments which you feel are relevant to this study. (Please feel free to use attachments, if necessary). _____

APPENDIX B. SUMMARY OF GRAVEL MINING AND SEDIMENT TRANSPORT STUDIES ON MAJOR ARIZONA RIVERS

Previous studies on Arizona river systems provide a valuable source of data for the river-basin classification work. Such studies are also useful in identifying and evaluating different engineering methodologies that have previously been used to conduct analyses of in-stream gravel mining operations.

In order to locate such studies, the questionnaires that were sent to regulatory agencies, consulting engineers, and gravel mining companies (see Appendix A) included a request for data or reports that the questionnaire recipients thought would be pertinent to this research project. Unfortunately, the response to this category of requested information was minimal. Accordingly, SLA had to rely heavily on previous sediment transport, hydraulic, and gravel mining studies prepared by SLA. This accounts for the large number of SLA reports referenced in this section.

Studies selected for inclusion in this chapter were based on their relation to major Arizona river systems that have a high potential for in-stream sand and gravel mining. The data that has been collected relative to previous studies is summarized according to two categories:

- In-Stream Sand and Gravel Mining Studies
- Hydraulic/Sediment Transport Studies

Each of the following studies is described by: 1) name; 2) location; 3) date; 4) consultant preparing study; 5) name of client; 6) synopsis of results; and 7) list of computer models used in the study.

B.1 In-Stream Sand & Gravel Mining Studies

1. Analysis of Effects of Sand & Gravel Mining Activities on the Stability of the Oracle Highway Bridge

Location	:	Rillito River, Tucson, Arizona
Date	:	January 1981
Consultant	:	Simons, Li & Associates, Inc.
Client	:	Pima County Department of Transportation & Flood Control District
Synopsis	:	Study identified and examined causes of past, present, and future degradation and/or aggradation at the Oracle Highway bridge and, in particular, examined the effects of gravel mining activities on the stability of the bridge.
Computer Models:		HEC-2, PIT

2. Impact of Gravel Mining on the Proposed Salt River Channelization Project

Location : Salt River, Phoenix, Arizona
Date : November 1980
Consultant : Anderson-Nichols & Colorado State University
Client : U.S. Army Corps of Engineers, Sacramento District
Synopsis : A physical model was constructed to simulate the impact of in-stream gravel pits on the stability of a proposed channelization scheme for the Salt River from I-10 to Sky Harbor Airport. The model results were used to develop guidelines to implement proper control of these mining operations to avoid adverse impacts.
Computer Models: None.

3. Sand and Gravel Mining Guidelines
Location : Salt and Gila Rivers, Maricopa County
Date : July 1980
Consultant : Boyle Engineering Corporation
Client : U.S. Army Corps of Engineers, Los Angeles District
Synopsis : Develops guidelines for sand and gravel extraction from the Salt and Gila Rivers in order that such guidelines might be used to reduce flood damages associated with in-stream mining. The report discusses hydraulic and erosion processes associated with such operations and outlines mitigation measures to minimize adverse impacts on the river system.

4. An Evaluation of Effects of Excavations in the Vicinity of the I-10 Salt River Bridge on the Flow Regime and Local Scour at the Bridge
Location : Salt River, Phoenix, Arizona
Date : December 1980
Consultant : W.R. Bruesch, Arizona Department of Transportation
Client : Arizona Department of Transportation
Synopsis : Presents an extensive photo-documentary on the changes in river regime near the I-10 bridge. These photos illustrate changes in flow patterns resulting from man's activities in and adjacent to the river channel. A subjective evaluation of the effects of changes in the flow regime on local scour at the bridge is also presented.
Computer Models: None.

5. Hydraulic and Geomorphic Analysis and Mine Plan Study for the Blue Circle Arizona, Inc. Pantano Wash Lease Site

Location : Pantano Wash, Pima County, Arizona
Date : January 1986
Consultant : Simons, Li & Associates, Inc.
Client : Blue Circle Arizona, Inc.
Synopsis : This study was a hydraulic and geomorphic analysis to assess the feasibility of developing a 200-acre sand and gravel mining operation along Pantano Wash. The study resulted in a mining plan that included measures to mitigate adverse impacts to the river system.
Computer Models: HEC-2, QUASED

6. Engineering Analysis of In-Stream Gravel Extraction From the Agua Fria River, Vicinity of Indian School Road and Camelback Road
Location : Agua Fria River, Phoenix, Arizona
Date : September 1985
Consultant : Simons, Li & Associates, Inc.
Client : Flood Control District of Maricopa County
Synopsis : This study presents a detailed analysis of river system impacts that would be expected to accompany the proposed excavation of two large gravel pits on either side of the Indian School Road Bridge. The analysis addresses both short- and long-term impacts that would be expected upstream and downstream of the proposed pits. The report is based on a head-cut and trap efficiency analysis of the two pits as well as a sediment routing model which was used to predict a downstream degradation profile of the riverbed.
Computer Models: HEC-2, QUASED, SETTLE

7. Development of Qualitative Guidelines for Sand and Gravel Mining in Salt, Gila and Agua Fria Rivers
Location : Salt, Gila and Agua Fria Rivers, Maricopa County, Arizona
Date : June 1980
Consultant : Simons, Li & Associates, Inc.
Client : Boyle Engineering Corporation
Synopsis : This study focuses on the following objectives: (1) explain physical processes governing mechanics of the gravel pit during low, medium and high flows, considering both headcutting upstream and degradation downstream of the pit, along with the significance of the depth, size and volume of the pit; (2) provide a typical example of a simulation run of real-time response for an assumed storm hydrograph and a hypothetical gravel pit; (3) suggest a qualitative guide for sand and

gravel extraction in the Salt, Gila and Agua Fria Rivers; and (4) recommend a study plan for developing a quantitative guide for sand and gravel extraction in the Salt River as a function of sediment supply and transporting capacity of the river.

Computer Models: None.

8. Preliminary Engineering Analysis of In-Stream Sand and Gravel Extraction From Three Sites on the Salt River

Location : 67th Avenue, 48th Street, and Indian Bend Wash Confluence, Salt River, Maricopa County, Arizona
Date : November 1985
Consultant : Simons, Li & Associates, Inc.
Client : The Tanner Companies
Synopsis : An engineering investigation was made of three potential in-stream gravel pit locations on the Salt River in order to identify any utility conflicts and river mechanics problems that might restrict the excavation limits at each site. The report utilizes data from a physical-model study on the Salt River to: 1) establish recommended excavation limits (vertically and horizontally); and 2) to determine the maximum permissible yield from each pit.
Computer Models: None.

9. Sand and Gravel Mining Feasibility Study for The Tanner Companies - Los Reales/Pantano Wash Site

Location : Pantano Wash, Pima County, Arizona
Date : February 1986
Consultant : Simons, Li & Associates, Inc.
Client : The Tanner Companies
Synopsis : This report presents the results of a hydraulic and geomorphic analysis to assess the feasibility of realigning a one-mile section of Pantano Wash to allow for expansion of an existing gravel pit. Bank protection and erosion buffer zones were recommended as mitigation measures to prevent adverse river system impacts that might result from the proposed pit expansion.
Computer Models: HEC-2, QUASED

10. Erosion and Sedimentation Analysis of Columbia Pit and San Xavier Pit in the Santa Cruz River, Tucson, Arizona

Location : Santa Cruz River, Tucson, Arizona
Date : 1980
Consultant : Simons, Li & Associates, Inc.
Client : Cella, Barr, Evans and Associates

Synopsis : This report presents an analysis of the hydrologic, long-term geomorphic, hydraulic, and erosion and sedimentation processes for the river system. Aerial photographs and hydrologic records were used to determine gradual changes in the channel alignment and configuration that were occurring in the Santa Cruz River through the study areas. The response of both the river and the gravel pits during a 100-year flood was analyzed for a variety of possible gravel pit configurations and management schemes by using a water and sediment routing procedure developed by Simons and Li (1979). The long-term changes in the system and the changes resulting from a severe event (a 100-year flood) were used to make recommendations for engineering control measures for preventing any harmful interaction between the gravel pits and the Santa Cruz River.

Computer Models: HEC-2, PIT

11. Study of Gravel Mining Impacts, Verde River at Cottonwood, Arizona

Location : Verde River at Cottonwood, Arizona
Date : May 1985
Consultant : Simons, Li & Associates, Inc.
Client : Yavapai County Flood Control District
Synopsis : This study presents an engineering analysis of river system impacts associated with in-stream gravel mining on the Verde River at Cottonwood. The analysis was specifically structured to address headcutting upstream of the gravel pit, bank erosion, shifting of the channel alignment, and downstream channel degradation. Extensive use was made of historical aerial and ground photographs, historical bed profiles and hydrologic data.
Computer Models: HEC-2, MPM

12. Engineering Analysis to Establish Excavation Limits for In-Stream Extraction of Sand and Gravel Between 51st Avenue and 59th Avenue on the Salt River

Location : Salt River, Maricopa County, Arizona
Date : January 1986
Consultant : Simons, Li & Associates, Inc.
Client : Arizona Crushing Company
Synopsis : This report presents the development of an excavation plan for extracting sand and gravel from a specific reach of the Salt River floodplain. Excavation limits, both

vertical and horizontal, were developed to reduce the potential for creating a river system response, which would have a high probability of causing damage to nearby utility lines and a major bridge structure.

Specifically, the study addressed potential damage that might result from pit-induced headcutting, downstream scour, and lateral erosion. Using physical model study data developed by the principals of SLA, excavation limits for pit depths of 20 feet, 40 feet, and 60 feet were established for the site. The excavation limits were offset a sufficient distance inside the property boundaries so as to minimize offsite erosion and scour damage. Approximate excavation volumes were then computed in order that a determination could be made of the feasibility for commercial sand and gravel extraction at the site.

Computer Models: None.

13. (Exact title unknown, information provided by the Pima County Department of Transportation and Flood Control District)

Location	:	Santa Cruz River, Pima County, Arizona
Date	:	1975
Consultant	:	Cella, Barr, Evans & Associates, Inc.
Client	:	Granite Construction Company
Synopsis	:	This study examined a proposal to modify the river channel near the approach to an existing bridge. The excavation was to be done by Granite Construction Company.
Computer Models:		HEC-2

14. (Exact title unknown, information provided by the Pima County Department of Transportation and Flood Control District)

Location	:	Santa Cruz River, Pima County, Arizona
Date	:	1981
Consultant	:	Dooley-Jones & Associates, Inc.
Client	:	San Xavier Rock and Materials
Synopsis	:	This study presented a mining plan for sand and gravel extraction from the overbank of the river. Forms of bank protection were investigated.
Computer Models:		HEC-2

15. (Exact title unknown, information provided by the Pima County Department of Transportation and Flood Control District)

Location : Rillito River, Pima County, Arizona
Date : 1978
Consultant : Cella, Barr, Evans & Associates, Inc.
Client : Pueblo Pebbles
Synopsis : This report was prepared to determine safe setback limits for a sand and gravel mining operation in the overbank of the Rillito River.
Computer Models: HEC-2

16. (Exact title unknown, information provided by the Pima County Department of Transportation and Flood Control District)
Location : Rillito River, Pima County, Arizona
Date : 1984
Consultant : Cella, Barr, Evans & Associates, Inc.
Client : Pueblo Pebbles
Synopsis : The gravel mining limits recommended in the 1978 study were exceeded. This new study presents additional engineering analyses required to justify further excavation.
Computer Models: HEC-2

17. (Exact title unknown, information provided by the Pima County Department of Transportation and Flood Control District)
Location : Pima County, Arizona
Date : 1986
Consultant : CMG Drainage
Client : Blue Circle
Synopsis : This study presents the results of a seepage analysis, river cross-sections, and historical photos that were used to determine a safe setback limit for an overbank sand and gravel operation.
Computer Models: None.

18. (Toby Allen-Pantano Wash - exact title unknown, information provided by the Pima County Department of Transportation and Flood Control District)
Location : Pantano Wash, Pima County, Arizona
Date : 1986
Consultant : Dooley-Jones & Associates, Inc.
Client : Toby Allen
Synopsis : Analysis of in-stream sand and gravel extraction. Details are unknown.
Computer Models: HEC-2, HEC-6, FLUVIAL 2

B.2 Hydraulic/Sediment Transport Studies

1. Santa Cruz River Mechanics Study - Rillito Creek to Cortaro Road

Location	:	Santa Cruz River, Pima County, Arizona
Date	:	September 1985
Consultant	:	Simons, Li & Associates, Inc.
Client	:	Tucson Sand and Soil, Inc.
Synopsis	:	This study was a hydraulic and geomorphic analysis conducted to assess the impact of channelization and realignment of the Santa Cruz River between the Rillito River confluence and Cortaro Road. Also contained within the plan was a proposal to widen the Santa Cruz River at the confluence with the Canada del Oro Wash to a width of approximately 1250 feet for the purpose of inducing sediment deposition in order to provide a source of mineable sand and gravel material. The objectives of this plan were to advance the economical development of the property as a sand and gravel mining operation, and to prevent future floods from causing additional bank erosion and lateral migration of the channel which has historically resulted in significant damage to private and public properties within the project area.
Computer Models:		HEC-2, QUASED

2. Hydraulic, Erosion and Sedimentation Analysis of Indian School Road Bridge Over the Agua Fria River

Location	:	Agua Fria River, Maricopa County, Arizona
Date	:	1982
Consultant	:	Simons, Li & Associates, Inc.
Client	:	Flood Control District of Maricopa County
Synopsis	:	This study addresses the failure of the Indian School Road Bridge during the February 20, 1980 flood on the Agua Fria River and investigates stability measures to prevent a recurrence of the failure. The three-level analysis applied to the ISRB failure included: (1) a qualitative geomorphic analysis; (2) a quantitative engineering geomorphic analysis; and (3) an application of a mathematical model to evaluate the potential local scour, general regional scour, and potential aggradation/degradation at the ISRB and the RID flume crossing. The results of the three-level analysis were used in a litigation suit involving nearby gravel mining com-

panies and were also used to develop mitigation measures to prevent future damage.

Computer Models: HEC-2, QUASED

3. Hydraulic and Scour Analysis of Salt River Bridge at Phoenix-Casa Grande Highway for Long-Term Protection Against Scour

Location : Salt River, Phoenix, Arizona
Date : 1980
Consultant : Simons, Li & Associates, Inc.
Client : Dames and Moore
Synopsis : Excessive scour caused settlement of the I-10 bridge piers during the February 1980 flood. This report analyzes the susceptibility of the pier foundations to scouring during future floods in order to evaluate alternative structural and/or nonstructural methods that could be used to protect the piers from such scouring. Structural alternatives that were analyzed include: (1) channelization using guidebanks; (2) a downstream grade control structure; and (3) control of side drainage flows. Nonstructural measures include: (1) control of gravel mining; and (2) operation of upstream reservoirs to regulate flow.
Computer Models: QUASED

4. Analysis and Design Study of the Agua Fria River

Location : Agua Fria River, Maricopa County, Arizona
Date : November 1983
Consultant : Simons, Li & Associates, Inc.
Client : Flood Control District of Maricopa County
Synopsis : A hydrologic, hydraulic, erosion and sedimentation study was completed for a nine-mile reach of the Agua Fria River from the confluence with the Gila River to the confluence with the New River. This investigation utilized a three-level approach which included: (1) a qualitative geomorphic analysis; (2) a quantitative engineering geomorphic analysis; and (3) a mathematical model simulation. The results of this analysis were used to design a channelization project for the Agua Fria River.
Computer Models: HEC-2, QUASED

5. Sediment Transport Analysis of Rillito River and Tributaries for the Tucson Urban Study

Location : Rillito River, Pantano Wash, Tanque Verde Creek, Sabino Creek, and Agua Caliente Wash, Tucson, Arizona

Date : February 1982
Consultant : Simons, Li & Associates, Inc.
Client : Pima County Department of Transportation and Flood Control District
Synopsis : A sediment transport analysis was conducted for approximately 45 miles of various river systems in the Tucson area in order to determine the potential for aggradation and degradation associated with the 10-year and 100-year floods. This information was used to help manage the watersheds and river systems in order to minimize the potential for adverse impacts resulting from development activity.
Computer Models: HEC-2, QUASED

6. Hydraulic and Geomorphic Analysis of the Proposed New Tanque Verde Road Bridge Over the Tanque Verde Creek
Location : Tanque Verde Creek, Tucson, Arizona
Date : 1981
Consultant : Simons, Li & Associates, Inc.
Client : Pima County Department of Transportation and Flood Control District
Synopsis : This report presents an engineering-geomorphic assessment (erosion/sedimentation) of the long-term bridge and river stability for a bridge that would pass a 100-year flood, versus a bridge that would pass a lesser flood. Hydraulic modeling investigated various bridge lengths and corresponding channel improvements. Environmental concerns for long-term river stability were also addressed.
Computer Models: HEC-2, QUASED

7. Sediment and Debris Transport Analysis at Eight Bridge Locations, Tucson, Arizona
Location : Magee Road, Thornydale Road, Ina Road, Craycroft Road, Sabino Canyon Road, Swan Road, Tanque Verde Road, and La Canada Drive, Tucson, Arizona
Date : 1981
Consultant : Simons, Li & Associates, Inc.
Client : Pima County Department of Transportation and Flood Control Division
Synopsis : This debris and sediment transport analysis developed information to: (1) evaluate the stability of the bridge structures; (2) determine the lateral-migration tendencies of the channel; (3) estimate the extent of expected general downstream channel scour; (4) determine the potential local scour around bridge piers

and abutments; and (5) estimate the long-term effects of sediment degradation and aggradation on the water-surface profile. The potential problems associated with vegetative debris were also studied, particularly in relation to possible partial blockage of the channel and increased local scour at the bridge sites.

Computer Models: HEC-2, QUASED

8. Scour/Migration Analysis of the Rillito River at Pontatoc Road

Location : Rillito River, Tucson, Arizona
Date : 1984
Consultant : Simons, Li & Associates, Inc.
Client : Brown and Caldwell Consulting Engineers
Synopsis : This study presents the results of a hydraulic and geomorphic analysis that was performed to determine the river response to a 10-, 25-, 50-, and 100-year flood. The analysis considered responses during previous floods for comparison with the quantitative responses which were estimated using locally accepted procedures.
Computer Models: HEC-2, QUASED

9. Hydraulic and sedimentation Analysis of the 7th Street Bridge over the Salt River

Location : Salt River, Phoenix, Arizona
Date : April 1981
Consultant : Simons, Li & Associates, Inc.
Client : RGA Consulting Engineers
Synopsis : This report presents the results of a sediment transport and scour analysis that was used to determine hydraulic bridge design parameters as a function of existing river conditions and a proposed channelization scheme. A three-level approach was used which included: (1) a qualita tive geomorphic analysis; (2) a quantitative engineering geomorphic analysis; and (3) a physical process model.
Computer Models: HEC-2, QUASED

10. Scour and Sedimentation Analysis of the Proposed Channelization of the Salt River for Protecting the Sky Harbor international Airport

Location : Salt River, Phoenix, Arizona
Date : 1980
Consultant : Simons, Li & Associates, Inc.
Client : Howard Needles Tammen and Bergendoff
Synopsis : Past floods caused significant damage to the Sky Harbor International Airport. The main runway was so severely damaged that

2400 feet of its length was unusable. As a result, a $10 million channelization project to protect the airport from a 100-year flood was formulated. Simons, Li & Associates, Inc. performed an analysis of the scour and sedimentation processes associated with the selected channelization alternative. The study considered the 100-year design event.

The investigation was carried out utilizing three levels: (1) a qualitative geomorphic analysis; (2) a quantitative engineering geomorphic analysis; and (3) a physical process model. The results of the analysis were used to provide recommendations to modify the proposed channelization scheme to prevent failure due to scour and sedimentation problems.

Computer Models: HEC-2, QUASED

11. River Response Analysis Associated With Rio Nuevo-Santa Cruz River Flood Control and Channelization Project

Location : Santa Cruz River, Tucson, Arizona
Date : 1981
Consultant : Simons, Li & Associates, Inc.
Client : Cella, Barr, Evans & Associates
Synopsis : Using a HEC-2 model prepared by Cella, Barr, Evans & Associates, SLA performed a three-level analysis to assess erosion and sedimentation problems which included qualitative geomorphic, engineering geomorphic and physical process model analyses. This information was used to answer questions regarding short-term and long-term responses to different flood events. The study concluded with an analysis of several design alternatives for bank protection.

Computer Models: HEC-2, QUASED

12. Canada del Oro Flood Control Project (Oro Valley), Arizona

Location : Canada del Oro Wash, Oro Valley, Arizona
Date : 1981
Consultant : Simons, Li & Associates, Inc.
Client : Arizona Department of Water Resources
Synopsis : This reconnaissance-level report addressed the flooding problems along a two-mile reach of the Canada del Oro Wash in the vicinity of the town of Oro Valley in Pima County, Arizona. The study involved: (1) review of existing hydrologic, hydraulic, erosion, and sedimentation information; (2) determination of existing and potential flooding problems in the study reach;

(3) evaluation of potential erosion and sedimentation problems using a sediment routing model; (4) formulation of flood control alternative plans; and (5) evaluation of alternative plans considering operation and maintenance, environmental factors, and economics.

Computer Models: HEC-2, QUASED

13. Sediment Transport Report for the New River and Skunk Creek

Location : New River and Skunk Creek, Maricopa County, Arizona

Date : January 1985

Consultant : Simons, Li & Associates, Inc.

Client : U.S. Army Corps of Engineers, Los Angeles District

Synopsis : In order to evaluate the impact of rapid urbanization and commercial/industrial development within the New River/Skunk Creek watersheds, the Corps of Engineers retained Simons, Li & Associates, Inc. (SLA) to prepare a comprehensive hydraulic/sediment transport/flood control study for nine miles of the New River (upstream of the confluence with the Agua Fria River) and three miles of Skunk Creek (upstream of its confluence with New River).

The study involved three levels of analysis: (1) qualitative geomorphic; (2) quantitative geomorphic; and (3) sediment routing. Existing conditions were first investigated in order to determine specific problem areas within the river systems. A flood control solution, prescribed by the Corps of Engineers, was then evaluated using a sediment routing model developed by SLA.

Computer Models: HEC-2, QUASED

14. Excavation Plan/Salt River Southbank Project

Location : Salt River, Phoenix, Arizona

Date : January 1986

Consultant : Born, Barrett & Associates

Client : DENRO LTD. DEVELOPERS

Synopsis : The information provided on this project by the City of Phoenix consisted of plan/profile sheets and river cross-sections which depict a river excavation and levee plan extending from the I-10 bridge to about 36th Street. The analysis consists of HEC-2 runs showing "before" and "after" hydraulic conditions in the river.

Computer Models: HEC-2

15. Hydraulic Analysis for Salt River Between 19th Avenue and 35th Avenue

Location	:	Salt River, Phoenix, Arizona
Date	:	October 1986
Consultant	:	Water Resources Associates
Client	:	Harding Greene, Ltd.
Synopsis	:	This report presents a hydraulic analysis of a river channelization scheme that was investigated as part of a plan to install a conveyor bridge across the Salt River. A scour analysis was also performed to determine the scour depth for the piers supporting the conveyor bridge.
Computer Models:		HEC-2

16. River Mechanics and Floodplain Analysis, Phase 1, East Papago Extension-SR217, Hohokam Expressway Extension-SR143

Location	:	Salt River, Phoenix/Tempe, Arizona
Date	:	June 1986
Consultant	:	Simons, Li & Associates, Inc.
Client	:	John Carollo Engineers
Synopsis	:	This is the first of a three-phase study which will determine design parameters for the East Papago/Hohokam Freeway alignments that encroach into the Salt River floodplain. The Phase 1 report presents a preliminary examination of river system impacts associated with these alignments and investigates mitigation measures (including major river channelization) that would protect the freeway system from flood damage. Increased scour effects around existing bridge piers are also examined. Subsequent phases of this study will provide a historical geomorphic analysis of the river and will include the development of a sediment routing model for this reach of the Salt River.
Computer Models:		HEC-2, QUASED

APPENDIX C. REVIEW OF LITIGATION RELATED TO IN-STREAM MINING

A review of litigation related to in-stream sand and gravel mining was performed in order to determine the general magnitude of this type of litigation and to investigate the factors that lead to such litigation. The following is a partial listing of pertinent court cases. This information has been gathered by SLA staff through review of news articles and verbal discussions with people associated with the cases.

A. Maricopa County Superior Court, Cause #C453677
Maricopa County and Roosevelt Irrigation District v. Allied Concrete, et. al.

Location: Agua Fria River downstream of Indian School Road Bridge, Phoenix, Arizona

Sand and gravel mining operations encroached into the river channel downstream of the Indian School Road Bridge and upstream of the Roosevelt Irrigation District (RID) canal flume. The in-stream gravel pits necessitated the construction of dikes to prevent inundation of these operations during periods of flow, thereby restricting the channel opening to approximately 500 feet. The Indian School Road Bridge failed during the flood of February 1980. The RID flume did not fail; however, significant degradation did occur at this location.

The County prevailed in an out-of-court settlement. The objective of the settlement was to return the river channel to a "natural state". The defendants agreed to 1) provide funds which would be used to channelize and stabilize the river at this location and 2) deed ownership of the river bottom over to the County.

B. Agua Fria River Materials v. Allied Concrete

Location: Agua Fria River downstream of Indian School Road Bridge, Phoenix, Arizona

Sand and gravel mining operations encroached into the river channel downstream of the Indian School Road Bridge. Property owned by the plaintiff was located downstream of the sand and gravel operation owned by the defendant. The plaintiff's property was inundated during the February 1980 flood, allegedly as a result of the upstream mining operation.

The defendant settled out of court.

C. Kane, Talent v. Maricopa County, United Metro

Location: Agua Fria River upstream of Glendale Avenue Bridge, Phoenix, Arizona

The Maricopa County Highway Department had constructed a bridge over the low-flow channel at Glendale Avenue. The approaches to the bridge consisted of fill which encroached into the floodplain. An in-stream sand and gravel mining operation was located upstream of the Glendale Avenue Bridge. The plaintiff owned a business located in the floodplain upstream of the approach roadway. The plaintiff's property was inundated during the flood of December 1978, allegedly due to the combined effect of flow diversions from the upstream sand and gravel operation and backwater caused by the roadway approaches and a restricted bridge opening.

The plaintiff prevailed in an out-of-court settlement.

D. City of Phoenix v. Union Rock & Materials

Location: Salt River at the Central Avenue Bridge, Phoenix, Arizona

A gravel pit was located at the northwest corner of the bridge and another mining operation was located upstream of the bridge on the south side of the river channel. The flood of December 31, 1965 damaged the bridge causing failure of a pier.

A negotiated settlement was reached restricting the limits of sand and gravel mining in the vicinity of the bridge.

E. Yavapai County v. Valley Concrete & Materials, Inc.

Location: Verde River in the vicinity of Cottonwood, AZ

During recent years, increased gravel mining activity by the defendent in the Verde River floodplain upstream of the roadway crossing to Dead Horse Ranch State Park caused the plaintiff concern over river system changes allegedly related to the extraction of sand and gravel. This concern focused primarily on increased bank erosion, the shifting of the low-flow channel alignment, downstream channel degradation, and environmental damage to the riverbanks.

Following the flood of October 1983, the plaintiff filed a suit and a criminal charge against the defendant for diverting the course of the river. The criminal charge was dropped before going to court when the parties reached an agreement to implement, on a specified schedule, a bank stabilization plan to mitigate the damage. When it was ascertained that the defendant was not proceeding on schedule with the agreed upon mitigation plan, the plaintiff revoked the defendant's operating permit and secured a Temporary Restraining Order (TRO) from the court. The TRO was later overturned when the court decided that it was not

convinced that the defendant's sand and gravel operation was the sole source of downstream property damage. The issue of damages is still to be heard.

F. Arizona State Land Department v. Valley Concrete & Materials, Inc.

Location: Verde River in the vicinity of Cottonwood, AZ

The plaintiff owns the Dead Horse Ranch State Park located downstream of the defendant's sand and gravel operation on the Verde River. During the flood of October 1983, environmental damage occurred at the park site. The plaintiff has filed a suit seeking monetary damages. The issue of ownership of the river bottom is also being tested. The plaintiff seeks sovereign ownership of the land located between the river's ordinary high water marks as part of a statewide effort to claim lands given to Arizona at the time of statehood under the Equal Footing Doctrine.

G. Pima County Superior Court Case No. 217116

Addison/Philips v. Churchman Trucking, Cienega Ltd., and Columbia Materials

Plaintiff prevailed.

H. Pima County Superior Court Case No. 178620

Bohman v. Estes

Plaintiff prevailed.

I. Pima County Superior Court Case No. 162577

Pima County v. John Cardi

The ruling stated that if an existing use creates a hazard to life or property, a permit is required.

J. Pima County Court Case No. 1855856

Charles Cindrich v. Pima County

The court ruled that the plaintiff must obtain a Floodplain Use Permit to mine sand and gravel within the Tanque Verde Wash.

K. Maricopa County v. Phoenix Sand & Rock

The defendant paid monetary damages and deeded over fifteen acres for channelization.

L. Wooten v. Phoenix Sand & Rock

The defendant paid monetary damages.

M. Mulcher v. Phoenix Sand & Rock

The defendant paid monetary damages.

N. Maricopa County v. Phoenix Sand & Rock

The case involves condemnation of sixty-six acres of land. Outcome pending.